



International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(1): 376-378
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www.orthopaper.com
Received: 15-11-2019
Accepted: 19-12-2019

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Analysis of factors affecting the radiological and functional outcome of proximal femoral nailing in unstable intertrochanteric fractures

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DOI: <https://doi.org/10.22271/ortho.2020.v6.i1g.1893>

Abstract

Introduction: The incidence of hip fracture continues to increase as the elderly population increases, as a result of the extension of the average life span. Intertrochanteric fractures have been treated successfully by various methods, and now we are in an era where functional rehabilitation of patients to their preinjury levels is of prime importance. Reconstruction-type proximal femoral nailing is one of the surgical techniques used to treat intertrochanteric fractures. This implant faces less criticism than the previous ones, but it also has its own disadvantages.

Aim: To analyze the factors that affect the functional and radiological outcomes of unstable intertrochanteric fractures treated by proximal femoral nailing and to identify the factors responsible for an abnormal gait pattern after union in some patients.

Materials and Method: Forty-two patients treated in our facility who were categorized as having unstable intertrochanteric fractures were followed up until radiological union was achieved and 16 patients who had abnormal gait patterns were further studied to find the factor responsible. Tip Apex Distance, lateral screw sliding/collapse, screw position in the neck, initial and final neck-shaft angles, quality of reduction by the modified Fogagnolo *et al.* criteria and functional outcomes based on Harris Hip Score were analyzed.

Results: The average Harris Hip Score in our study was 83.8. Thirty-eight patients did not have any complications, but 16 our patients had abnormal gait patterns at the final follow-up. The reason for the abnormal gait pattern was secondary varus collapse caused by excessive lag screw sliding.

Conclusion: The initial quality of reduction as recommended by Fogagnolo is the key factor to achieve a favorable outcome. Proximal femoral nail helps in early return to their preinjury status in most of the patients. It also prevents the varus collapse in unstable intertrochanteric fractures, given the screws are positioned ideally.

Keywords: Proximal femoral nail, Trendelenburg's gait, Tip apex distance (TAD), lateral screw sliding (LSS), screw position, neck-shaft angle, quality of reduction

Introduction

Hip fractures are one of the most devastating injuries in all age groups. Their incidence is very high nowadays due to the increase in longevity of the human population and lifestyle modifications. These fractures in the elderly are a major cause for morbidity and mortality in the elderly population, because of decreased physical capacity activities and concomitant systemic diseases, causing a significant burden to the individual, family and society. Until the past decade, fracture union had been a major concern irrespective of the deformities and functional disabilities that the patient might face after the union.

Intertrochanteric hip fractures account for approximately half of the hip fractures in the elderly and pose a number of management dilemmas depending on the fracture configuration and status of the bones [1-2]. The operative procedures for the reduction and fixation of intertrochanteric fractures are technically challenging. Re-operation rates of 4-12% have been reported following the gold standard technique of fixation with dynamic hip screw [3-5].

The re-operation rates are particularly high in patients with unstable fractures. Re-operations are usually performed for medialization of the femoral shaft following mobilization of the

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patients. 3–6 The importance of the integrity of the lateral femoral wall in intertrochanteric fractures has come up during the last decade. Intertrochanteric fractures associated with fracture of the lateral femoral wall are now considered as a special group and integrity of the lateral femoral wall is considered to be an important indicator of stability and prognosis^[3, 4].

AIM

To analyze the factors that affect the functional and radiological outcome of unstable intertrochanteric fractures treated by proximal femoral nailing and to identify the factor that caused an abnormal gait pattern in some patients.

Materials and Methods

This study included 42 patients, who were categorized as having unstable intertrochanteric fractures according to the AO/OTA criteria and managed with PFN with an average follow-up of 30 months. All patients were operated with a standard PFN by closed reduction using a fracture table with a c-arm. The quality of reduction based on the modified Fogagnolo *et al.* criteria, screw position, and the tip–apex distance (TAD) was calculated based on intra-operative photographs. All patients were followed up at regular intervals, until evidence of union based on plain radiographs. Those with Trendelenburg's were followed up further to analyze the factors that caused the gait abnormality. Abductor power was tested during the final follow-up, charting was prepared according to the MRC grading. The radiological assessment included analysis of the quality of reduction, implant positioning and fracture consolidation. Implant positioning was assessed by means of the tip–apex distance^[15], lateral screw sliding, and screw position. The reduction was considered to be ideal when the neck-shaft angle on the AP radiograph was between 125° and 135°. The secondary varus collapse was measured as the difference between the neck-shaft angles obtained from the radiograph taken immediately after the surgery and anteroposterior radiograph taken at the final follow-up.

The influence of lag screw placement on favorable functional outcomes was considered for analysis, by Tyllianakis *et al.* method.

The lateral screw slide was measured using the modified nail axis reference method (modified NAR). X-rays taken immediately after surgery and in the final follow-up were compared, and the final difference was documented. The post-operative reduction was assessed using a criterion based on a study by Fogagnolo *et al.* who modified Baumgartner *et al.*'s criteria, where they consider alignment and displacement as

criteria for assessing the quality of reduction^[3]. The functional assessment was performed using the Harris Hip Score.

Results

For the 38 patients in whom the union was achieved, the average union time was 21.5 weeks. For the 4 patients with nonunion, revision surgery was performed. Where the union was achieved, gait analysis during their final follow-up revealed that 22 patients reached the normal pre-injury status of walking. Sixteen patients experienced abductor weakness and Trendelenburg's gait and were followed by further to identify the parameter responsible for this deficit.

The mean tipapex index was 18.5mm, and the TAD for most of the patients was > 25 mm. The tips of the lag screw in most of the cases were in the infero-central quadrant (Ideal Quadrant {8}) comprising 68.6%. The other quadrants were 4, 5, 7neck-shaft and 9.

From the radiographic evaluation, the mean neck-shaft angle immediately after the surgery was 131.8°. The reduction after the surgery was considered ideal in 33patients, while varus reduction was found in 3 cases. After the radiological union, the mean neck-shaft angle was 126.6°. Secondary varus collapse occurred in 9 cases where 3 patients who had valgus angulation at the time of reduction fell into the ideal category after secondary varus collapse, 3 patients who had an ideal initial neck-shaft angle collapsed to varus, and 3 patients who had varus angulation still worsened and failed. The average secondary varus collapse during follow-up was 5.8°.

The mean lateral screw sliding as measured by the modified NAR method was 3.8mm. The average lateral screw sliding for the 16 patients who had Trendelenburg's gait was 7.8mm.

In our study, 38 cases exhibited good reduction postoperatively and 3 cases showed acceptable reduction and 1exhibited poor quality of reduction based on Fogagnolo *et al.*'s criteria. All 4 who did not achieve good initial reduction faced complications (2 screws cut out, 1 reverse Z, and 1 Z effect).

In terms of the functional assessment at the time of union, the average Harris Hip Score for all patients was 83.8, with an excellent outcome in 22 cases, a good outcome in 11 cases, the reasonable outcome in 5 cases, and poor outcome in 4 cases. Twenty-nine patients in our study returned to their pre-injury job with no functional difference. The functional outcome was analyzed using the Harris Hip Score. Fractures of 38 patients united with a favorable outcome in 71.7%. Five patients achieved a reasonable union and 4 faced complications and their outcome was poor.

Table 1: Outcome analysis table

Parameters	Valgus		Normal			Varus		
Neck Shaft Angle (Initial)	6		33			3		
Neck Shaft Angle (Final)	Valgus		Normal			Varus		Failed
	3		30			5		4
Tip Apex Distance	<1.5mm		1.5-2.5mm			>2.5mm		
	11		19			12		
Lateral Screw Sliding	<3mm		3-5mm			>5mm		>5mm [Failed]
	15		8			15		4
Screw position	I	II	III	IV	V	VI	VII	VIII
	0	0	0	1	11	0	1	28
Quality of Reduction	Good		Acceptable			Poor		
	38		3			1		
Gait Pattern	Normal		Trendelenburg's			Antalgic/ Failed		
	22		16			2/2		

Discussion

Intertrochanteric fractures were previously associated with high morbidity rates, either temporary or permanent. With the advent of newer surgical techniques, the mortality and morbidity rates have come down drastically. Although functional results have become better with the current techniques, we are in an era where we still have to refine the techniques for the betterment of the functional outcome. All surgical techniques have their own complications that result in morbidity.

Schipper *et al.* report that the main reason for the occurrence of the cut-out is an unsatisfactory initial reduction, generally with varus presentation^[6]. As well as favoring Trendelenburg gait in a varus alignment, all 4 cases who were poorly reduced initially faced complications in our study.

Similar to our study, Herera *et al.* study showed an 8% collapse of the fracture site because of the lateral migration of screws. In our study we observed a 5.2% collapse due to the sliding of hip screws. This criterion proves that intramedullary implants are superior to other implants in preventing excessive collapse^[7]. We measured the difference in the lateral sliding of the screws using the modified NAR method as recommended by Nobuaki Chinzei *et al.*^[8] In our study, the average lateral screw sliding was 3.8mm, with a less than 3mm sliding in 21 cases, all of whom showed a very good functional outcome and early union. Among the 16 those who developed Trendelenburg's gait, the sliding was more than 5mm in 15 cases, with an average of 7.8mm.

Sixteen of our patients developed Trendelenburg's gait and abductor weakness even many months after fracture union, because of several factors, such as muscle strength due to nerve palsy or loss of abductor lever arm, power deficit due to injury burden, and insufficient rehabilitation. Altered hip biomechanics during bony union may be an important contributor, as described in the hip arthroplasty literature. During weight-bearing after intramedullary (IM) nailing, fracture fragments collapse despite the controlled sliding of the lag screw, which decreases both the abductor lever arm and medial femoral offset. Eventually, excessive lag screw sliding can lead to functional impairment because of the compromised abductor strength by decreased medial femoral offset and subsequently altered hip biomechanics as 15 of our patients had excessive lag screw sliding. The abductor lever arm is also affected by the vertical femoral offset as evidenced by the varus angulation in 5 of our patients. Paul *et al.* reported a greater difference in the abductor lever arm due to greater sliding of the lag screw and unstable fracture type predicted poor functional recovery. This implies that the shortening of anatomical femoral offset due to lag screw sliding in the united intertrochanteric fractures can have a negative effect on functional outcomes. Je-Hyun Yoo *et al.* in their study of 65 patients reported negative effects on the functional outcome due to excessive lag screw sliding in 26 patients^[9].

In our study, the quality of reduction according to the Fogagnolo *et al.* criteria^[10] influenced by the AO classification has affected the outcome with all 4(9.6%) cases who did not achieve a good initial reduction failed and of the remaining 38 (90.4%) cases where good reduction was achieved ended up with good outcome. In our study, patients who underwent osteosynthesis with a PFN, in unstable trochanteric fractures, presented a significantly faster return to their previous functional activity. As discussed above, 29 of our patients (nearly 70%) returned to their pre-injury functional status.

More than 85% of the patients in our study, experienced no or minimal pain after union with proximal femoral nailing. The remaining 15% had a poor functional outcome due to poor reduction of the fracture. The pain scale was influenced in our study by the quality of reduction, implant positioning, age and sex of the patient. Even if there are slight imperfections, PFN is a forgiving implant, giving good functional results even with unacceptable final radiological results.

Conclusion

Quality of initial reduction is the key factor to achieve favorable outcomes. Achieving medial or posteromedial cortical continuity is an important parameter as secondary varus collapse leads to complications or unfavorable outcomes. Patients should not be evaluated based on radiological outcomes alone, as the final radiological outcome does not correlate with the functional outcome. Precise calcar-oriented placement of screws will aid in preventing the excessive lag screw sliding and varus angulation, thus could avoid Trendelenburg's gait, and have better functional outcomes.

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